



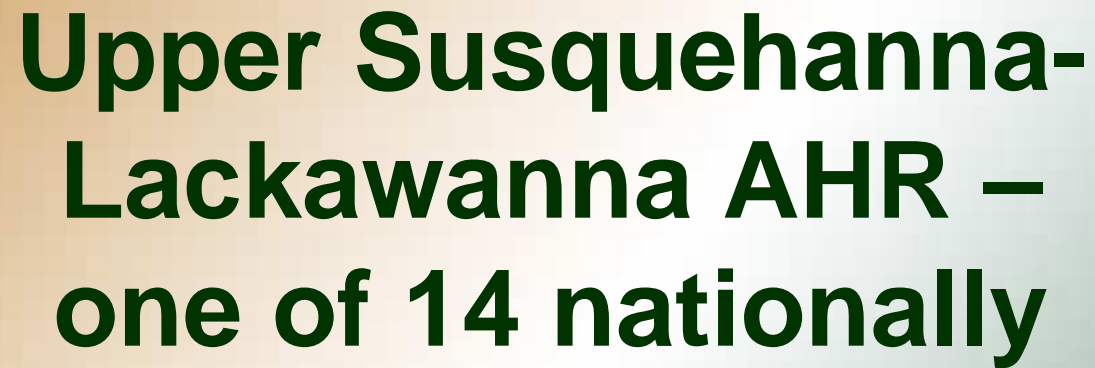
GIS Watershed assessments of an American Heritage River: a comparison of four spatial scales (Upper Susquehanna- Lackawanna River)

- Dale Bruns
- PA GIS Consortium (<http://www.pagis.org>)
- **USDA Rural GIS** (<http://www.ruralgis.org>)
- Wilkes Un. (Earth Sci. and Env. Eng. Dept.)
- College of Science and Engineering



Overview of Presentation:

- **Background on the American Heritage River**
- **Use of spatial scales and environmental gradients**
 - “Data mining” with EPA watershed indicators
 - 42 Tributary watersheds of the US-L AHR
 - 12 subwatersheds – chemistry, habitat, aquatic insects
 - Paired watersheds – and selective modeling (CityGreen)
 - Watershed: single river site – real time monitoring
- **Value of baseline monitoring (10 yr - perspective)**
 - What has it told us?
 - Does it help with emerging issues
 - (e.g., Marcellus Shale and natural gas development)



Designated in 1998; research pending in 1999

Legend:

- American Heritage River
- Note: Upper Mississippi River designation consists of 65 specific communities within this stretch.
- Associated Watershed
- Associated Counties (Hudson River)

Scale:

0 100 200 300 400 MILES
0 100 200 300 400 500 600 KILOMETERS

Inset Map:

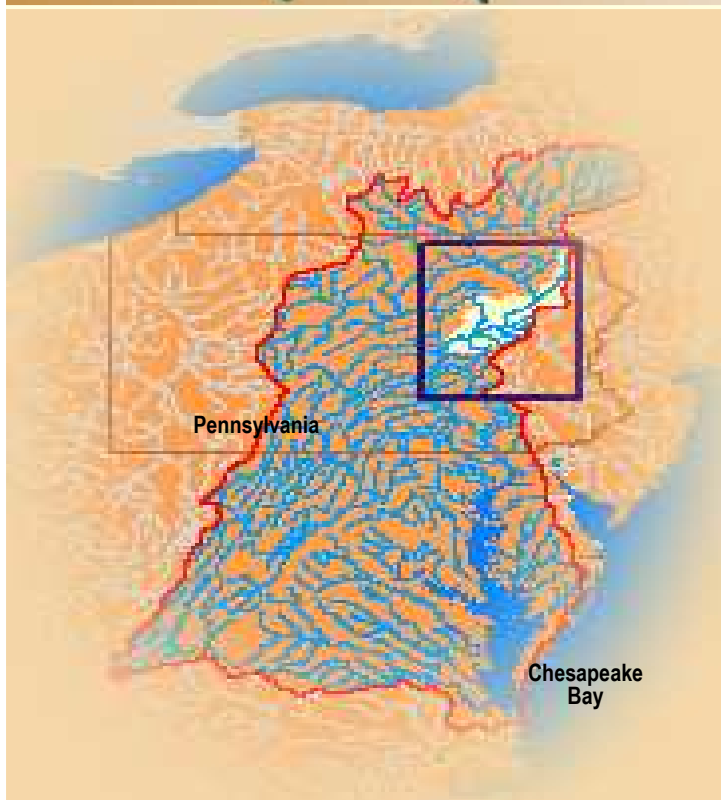
Hanalei River

Map Data:

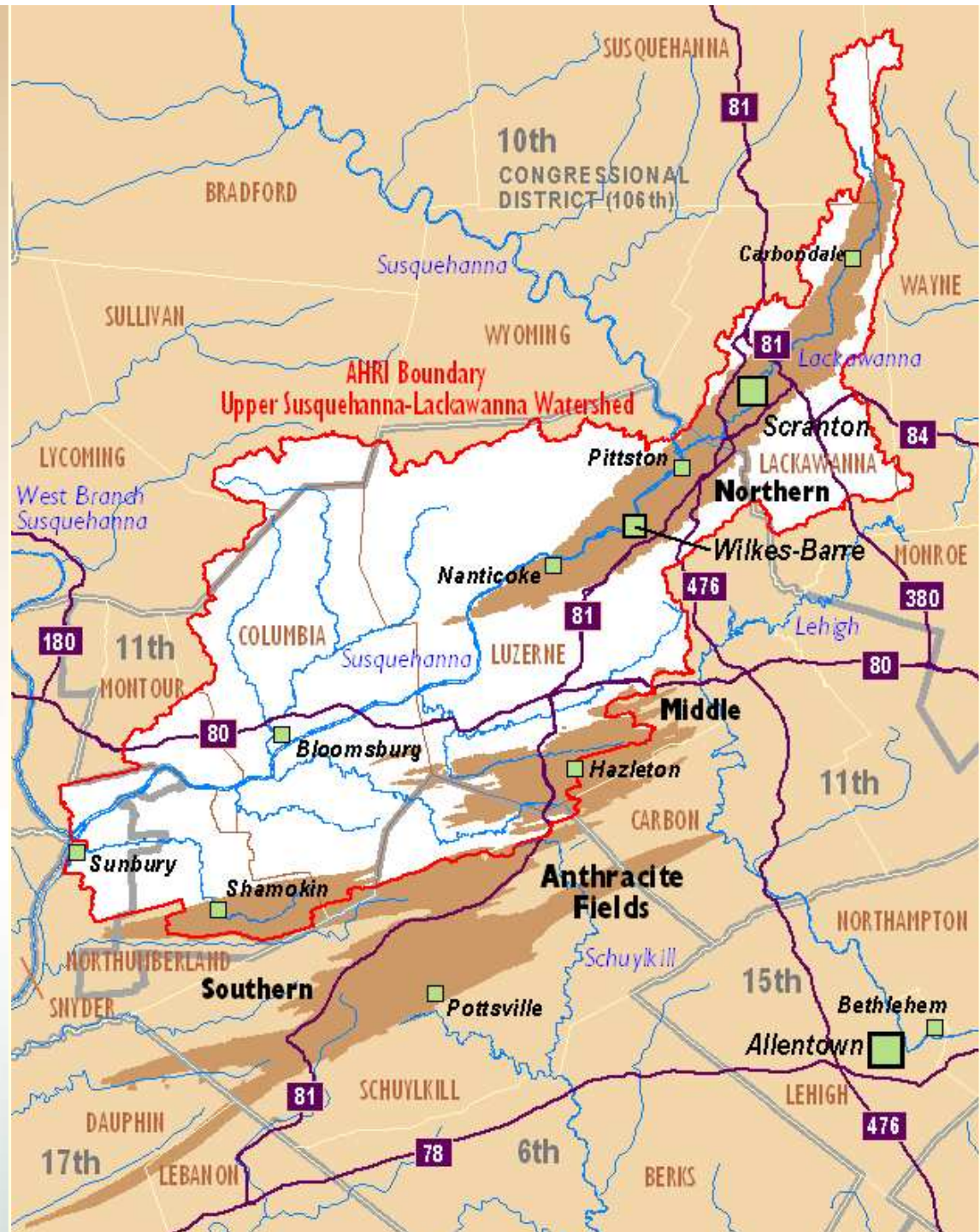
Base map data from the National Atlas of the United States of America Prepared by U.S. Geological Survey April 2004

nationalatlas.gov

USGS



Upper Susquehanna-Lackawanna Watershed's Relationship to the Chesapeake Bay Ecosystem





Environmental Problems

- **Watershed suffers** from more than 150 years of physical disturbance, sedimentation, acid mine drainage, and untreated urban runoff
- **Clean up costs:** \$2.5 billion (initially)
- **Specific Problem Areas (Land Use) – Initial (1999)**
 - Abandoned Mine Lands
 - Non-point AMD and AMD Outfalls
 - Combined Storm Overflows (CSOs)
- **Later concerns – more recent 2006 and 2008-2009**
 - Suburban Development (forests and agricultural) – runoff (Sierra Club: 1 of 10 worst areas for suburban sprawl)
 - Marcellus Shale and natural gas development



GeoSpatial Technologies for Coal Field Reclamation

GIS for Watershed Analysis

- **Characterize and Assess**

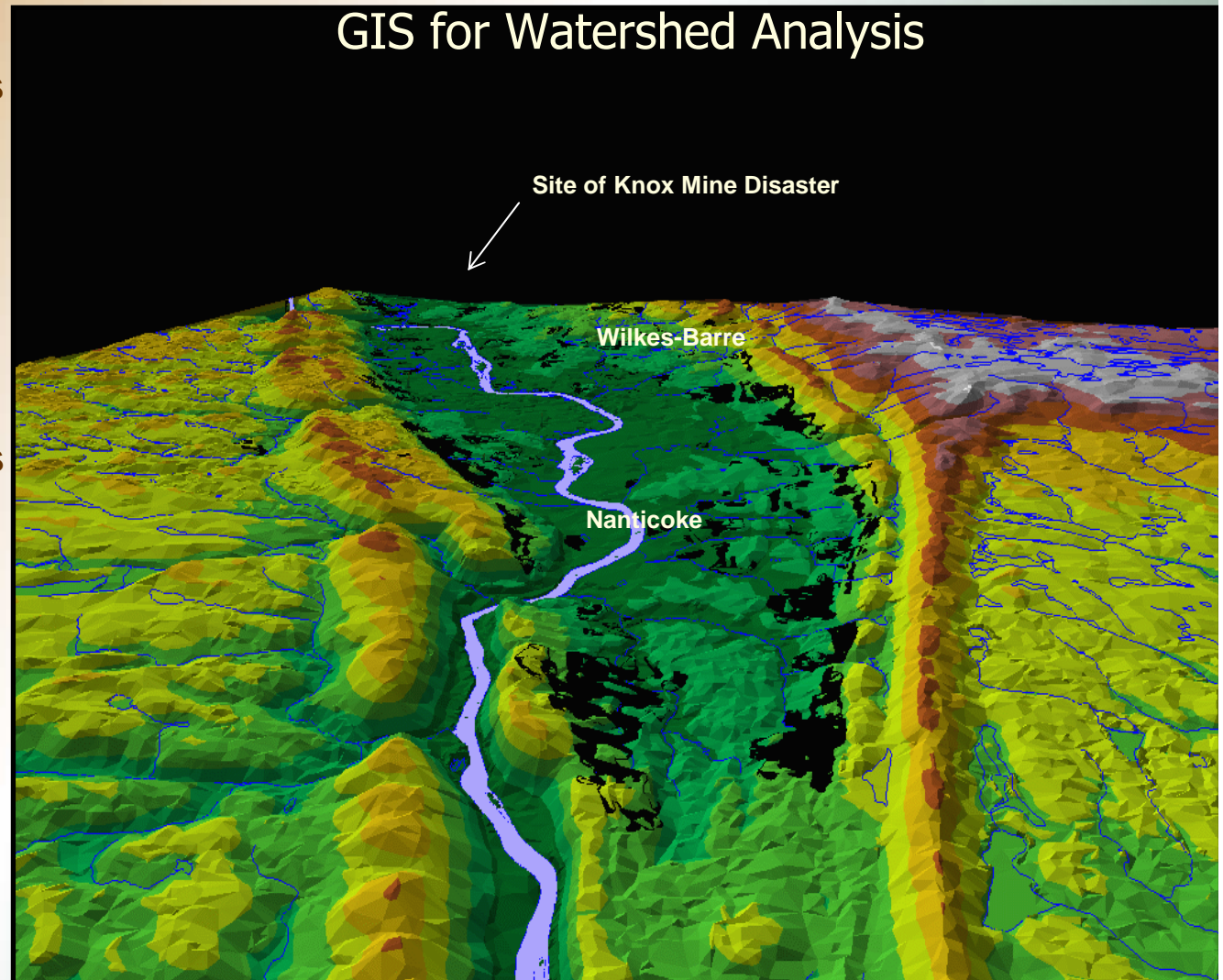
- Ecological conditions (2000 square mile area)
- Anthracite Fields
 - strip mines
 - mine pool
 - culm banks
 - acid mine outfalls

- **Geospatial Technologies**

- GIS and GPS
- Remote Sensing and Digital Photogrammetry

- **Watershed Analysis**

- provide first step to testing landscape-watershed indicators of pollution
- regional scale (federal) data





Filmclip: Knox Mine Disaster







Persistent Water Quality Problems

Severely degraded stream with urban debris and mining sediments



Mapping mine outfall locations with GPS technologies



GPS locations of water quality problems



Regional Landscapes - (5 State Area)

**Tributary
Watersheds
(10-400 sq.
mi.)**

**Local Stream
Reaches (e.g.,
300 m)**

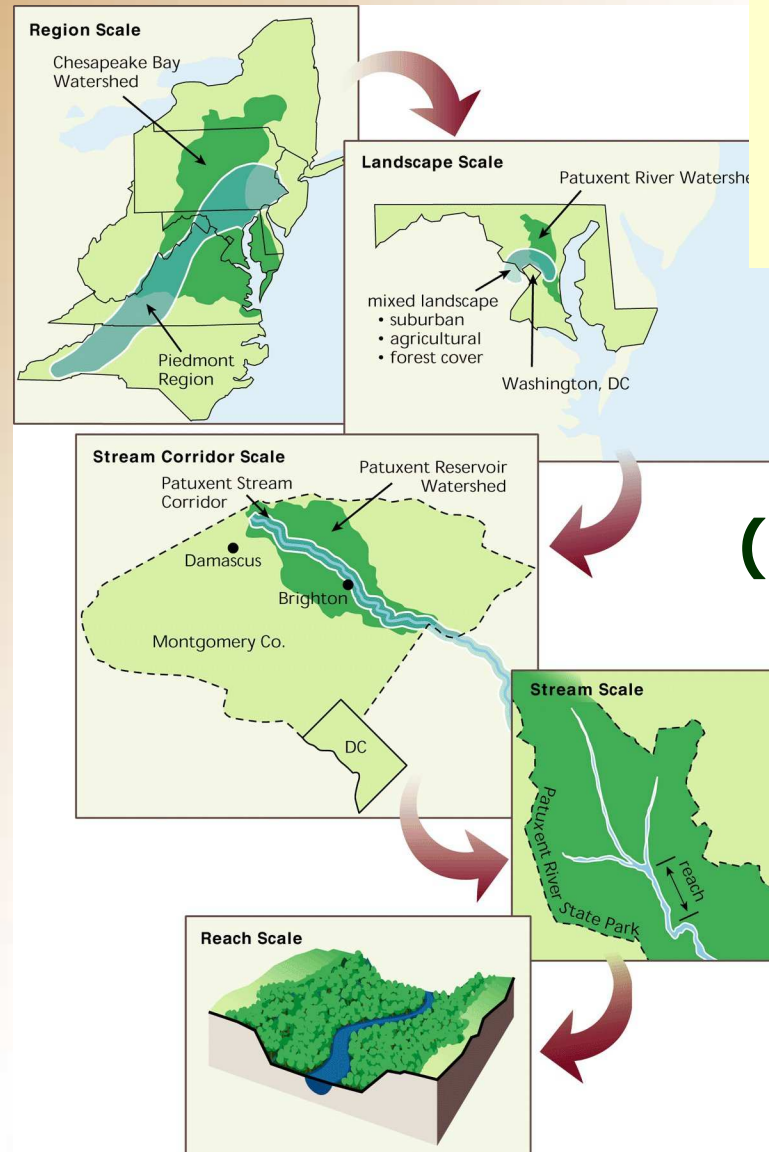


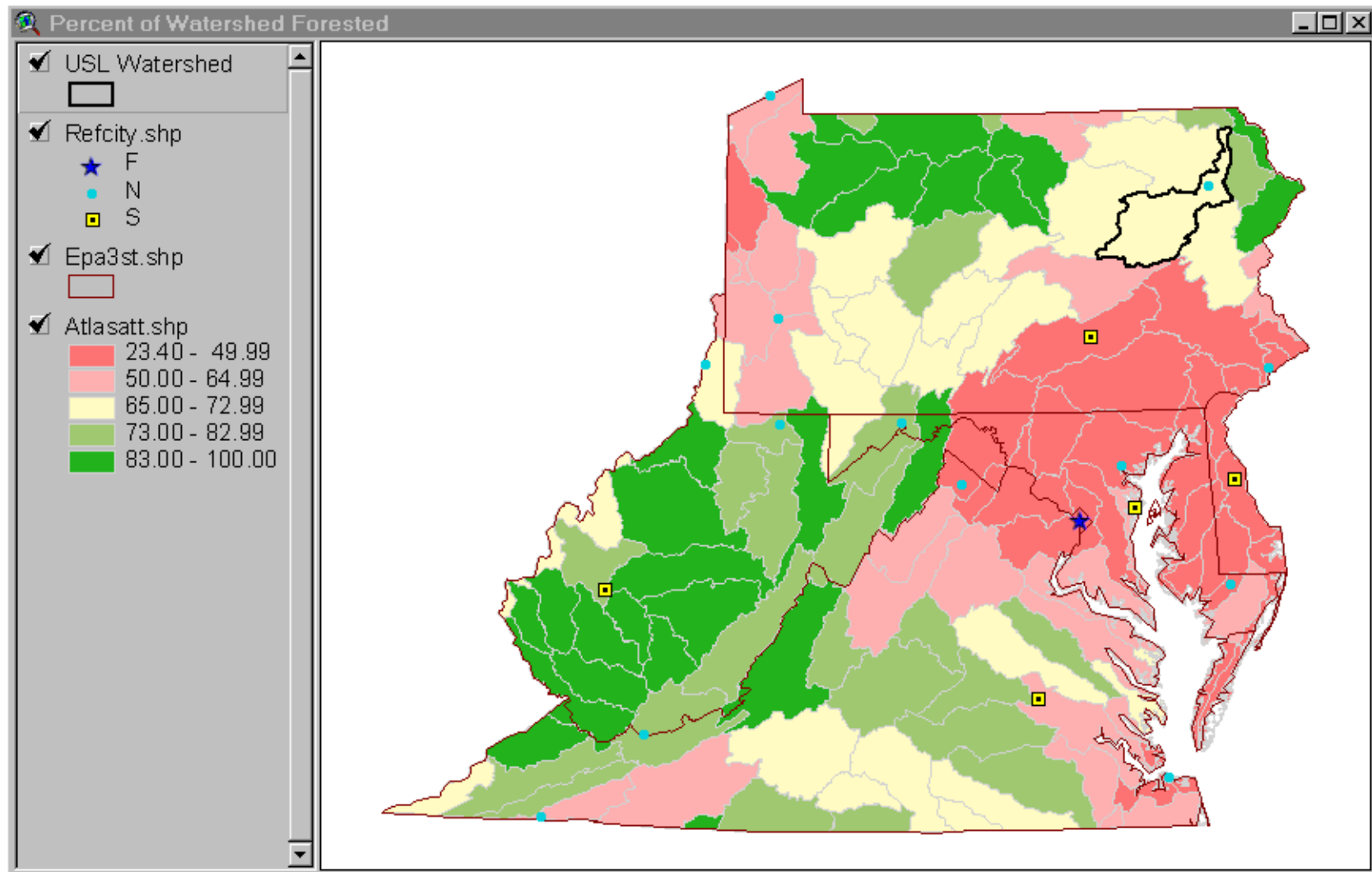
Fig. 1.2 -- Ecosystems at multiple scales. Stream corridor restoration can occur at any scale, from regional to stream reach.
In Stream Corridor Restoration: Principles, Processes, and Practices, 10/98.
Interagency Stream Restoration Working Group (FISRWG)(15 Federal agencies of the US).

Spatial Scales for Watersheds

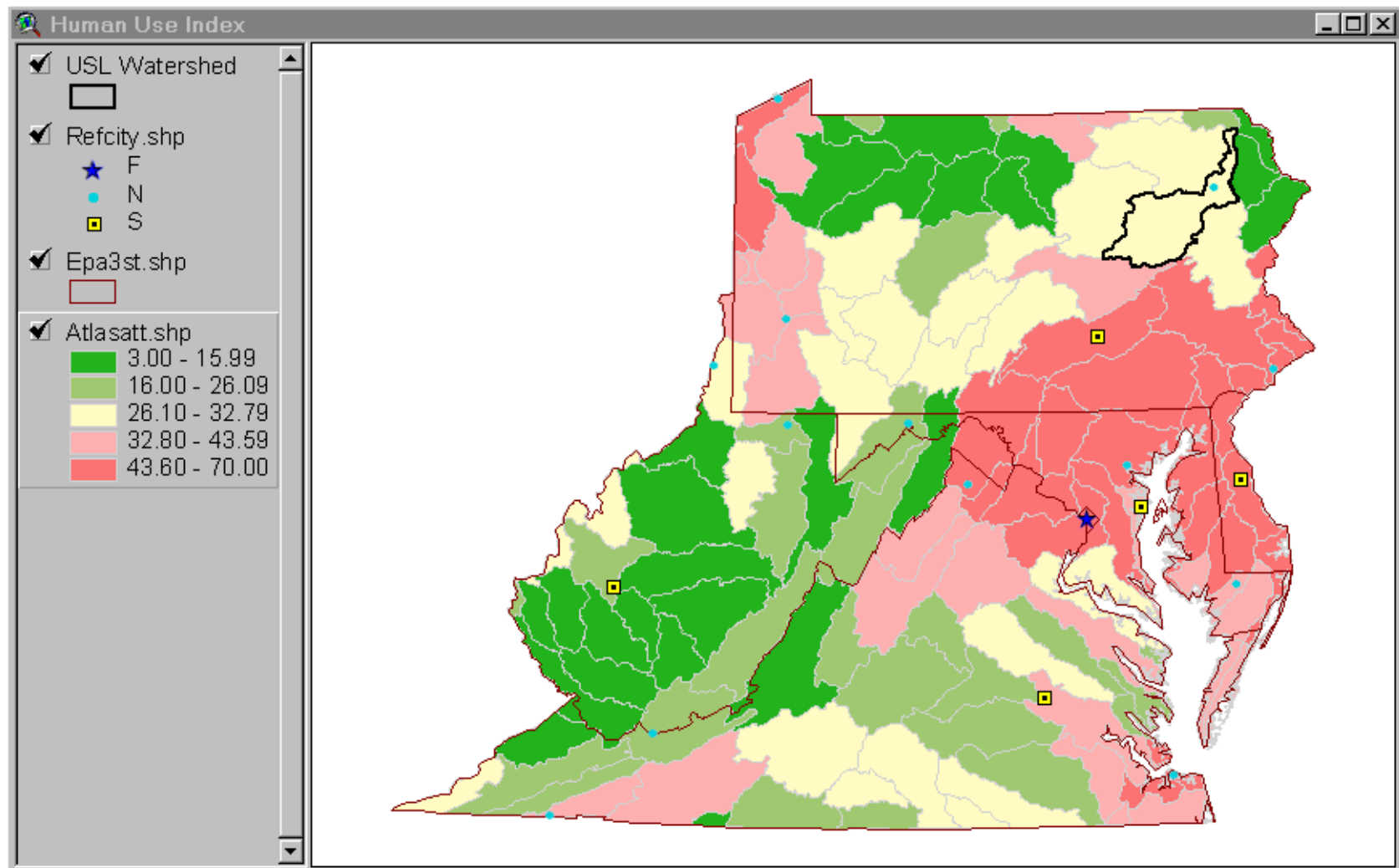
**Regional
Watershed
(2000 sq. mi.)**

**Local
Watersheds
(1-5 sq. mi.)**

EPA's Mid-Atlantic Ecological Assessment: Forest Land Cover



EPA's Mid-Atlantic Ecological Assessment: Human Use Index



**Regional
Landscapes -
(5 State Area)**

**Tributary
Watersheds
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**Local Stream
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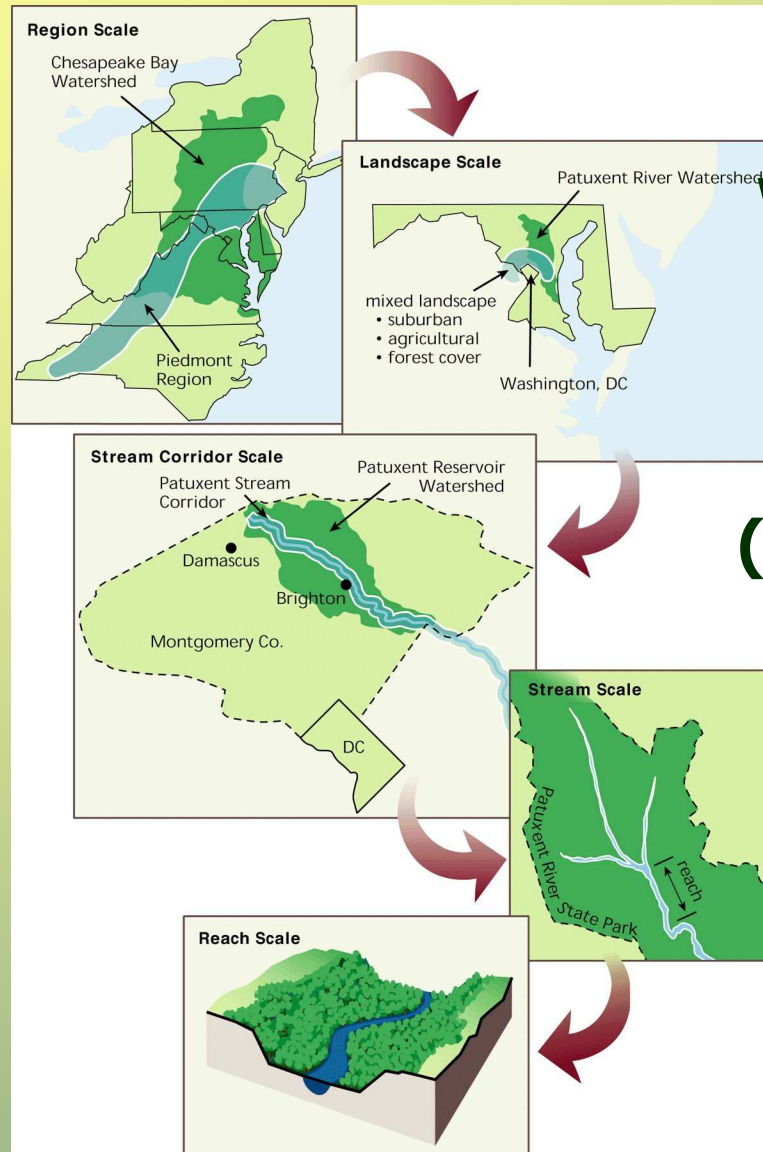


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**Spatial
Scales for
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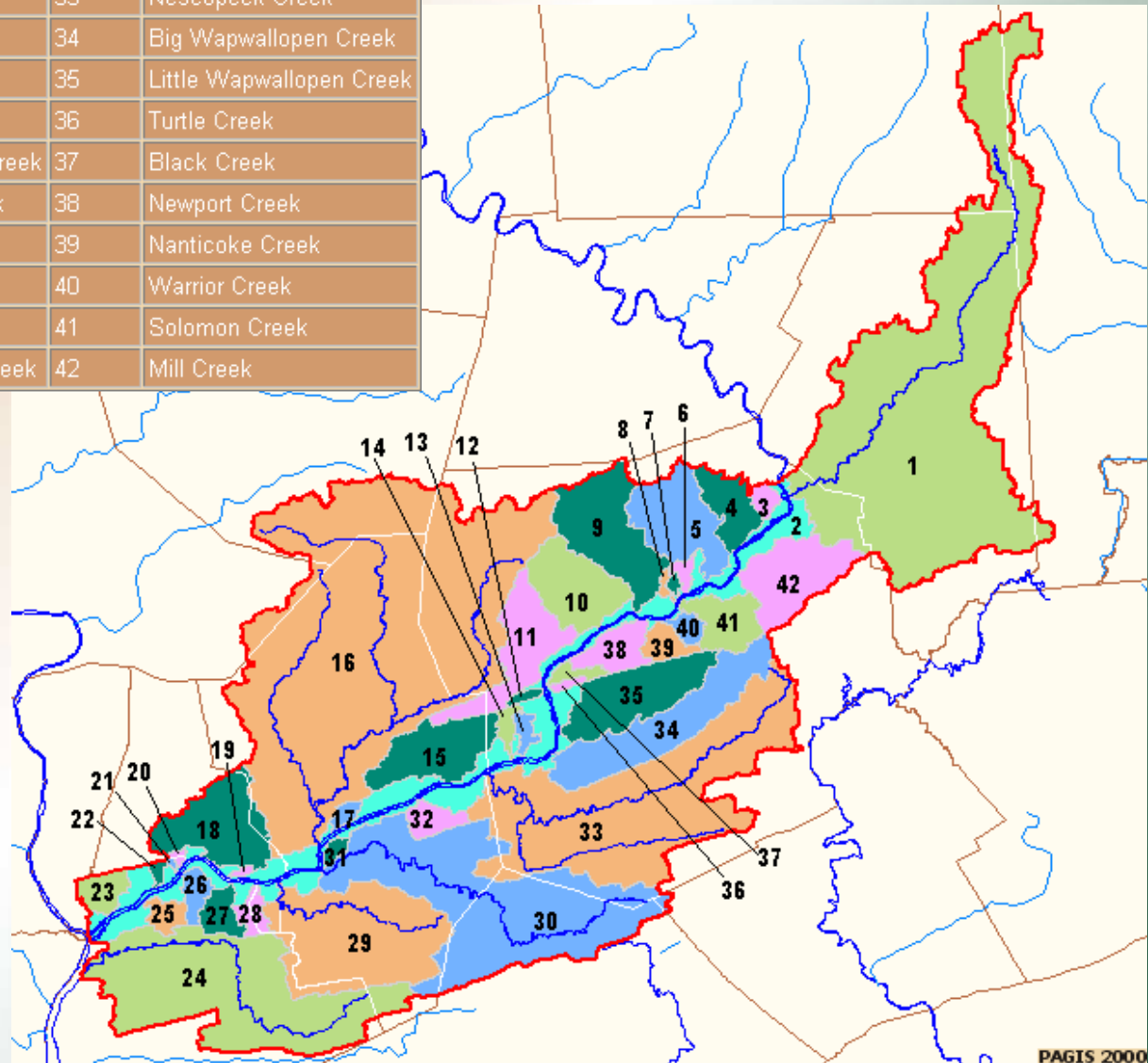
**Regional
Watershed
(2000 sq. mi.)**

**Local
Watersheds
(1-5 sq. mi.)**

PA GIS Consortium

Number	Name	Number	Name	Number	Name
1	Lackawanna River	15	Briar Creek	29	Roaring Creek
2	Susquehanna River	16	Fishing Creek	30	Catawissa Creek
3	Hicks Creek	17	Neals Run	31	Corn Run
4	Abrahams Creek	18	Mahoning Creek	32	Tenmile Run
5	Toby Creek	19	Toby Run	33	Nescopeck Creek
6	Brown Creek	20	Gaskins Run	34	Big Wapwallopen Creek
7	Wadham Creek	21	Raups Run	35	Little Wapwallopen Creek
8	Coal Creek	22	Packers Run	36	Turtle Creek
9	Harvey Creek	23	Lithia Springs Creek	37	Black Creek
10	Hunlock Creek	24	Shamokin Creek	38	Newport Creek
11	Shickshinny Creek	25	Gravel Run	39	Nanticoke Creek
12	Rocky Run	26	Kipps Run	40	Warrior Creek
13	Walker Run	27	Logan Run	41	Solomon Creek
14	Salem Creek	28	Little Roaring Creek	42	Mill Creek

Key to Tributary Sub-Watersheds



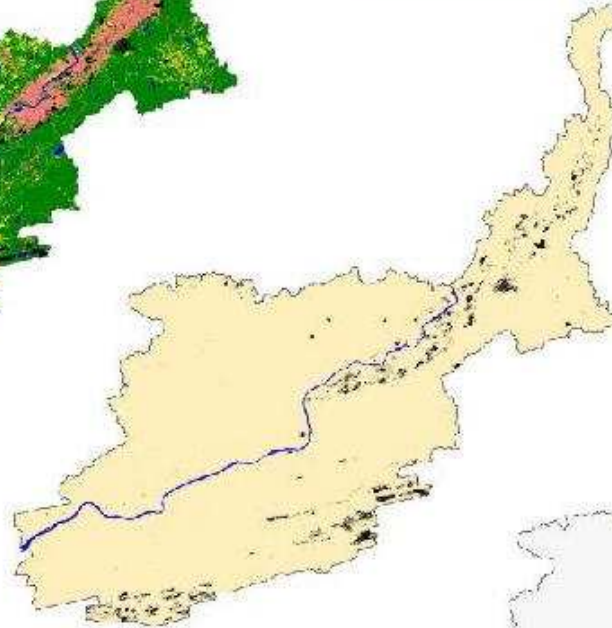
GIS Analysis of Watershed Characteristics

Upper Susquehanna-Lackawanna Watershed -- An American Heritage River

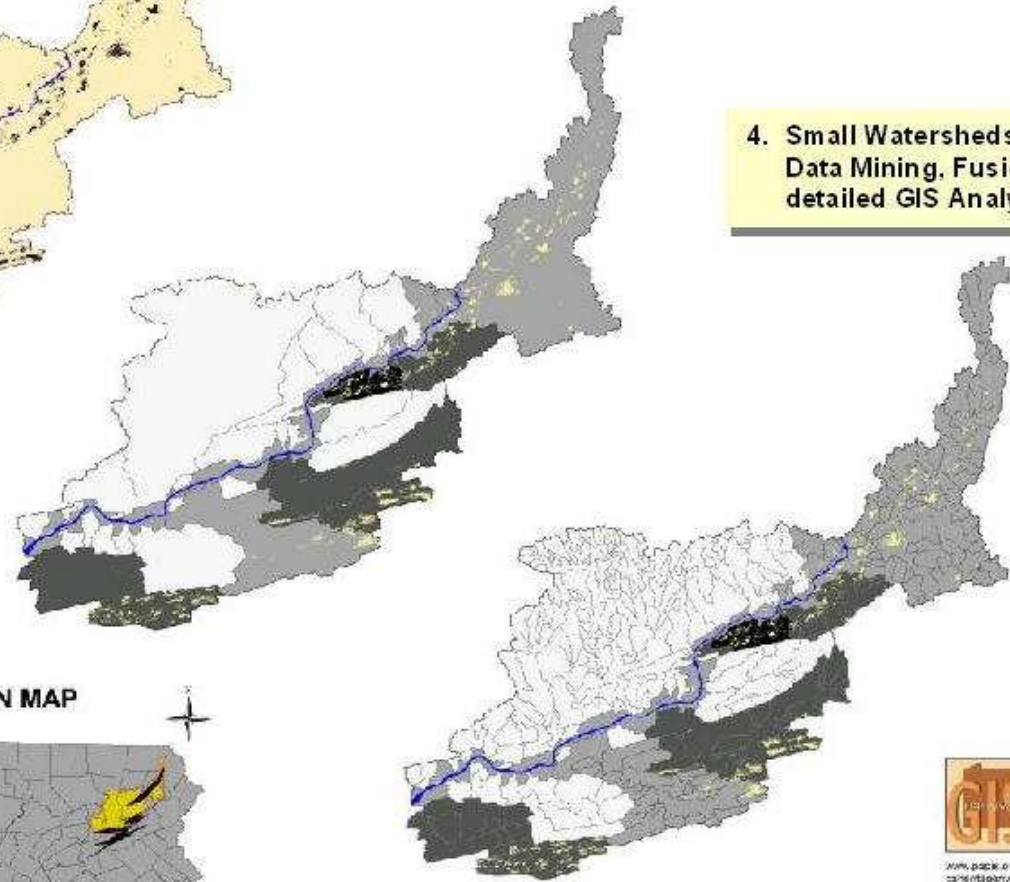
1. MRLC Land Use/Land Cover



2. Distribution of Abandoned Mine Lands (shown in black from MRLC) relative to the mainstem Susquehanna River



3. GIS Classification of Tributary Watersheds BLACK = Highest Percent Mining WHITE = Lowest Percent Mining YELLOW = Abandoned Mine Lands



4. Small Watersheds for Data Mining, Fusion and detailed GIS Analyses

Total Watershed Area Analysis
on 2000 Sq. Miles (Source: MRLC)
Colors relate to watershed 1 (MRLC Land Use / Cover)

LAND COVER	% of TOTAL
FOREST	67%
AGRICULTURE	23%
URBAN	6%
MINING	2%
WATER	2%

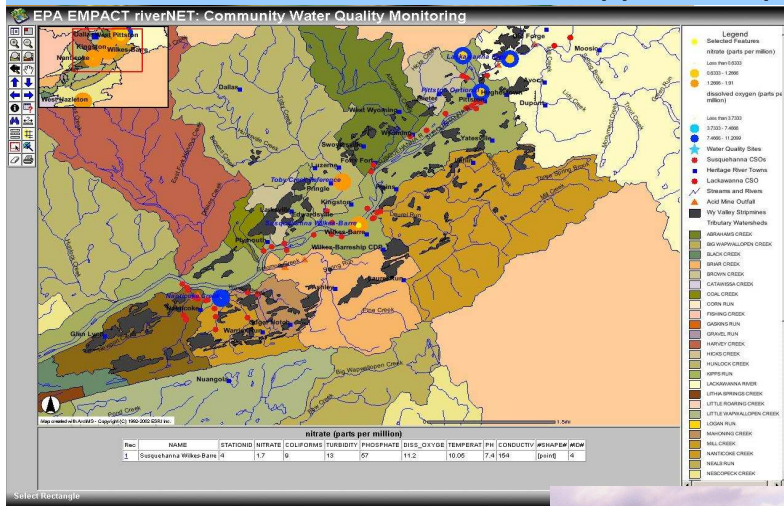
LOCATION MAP



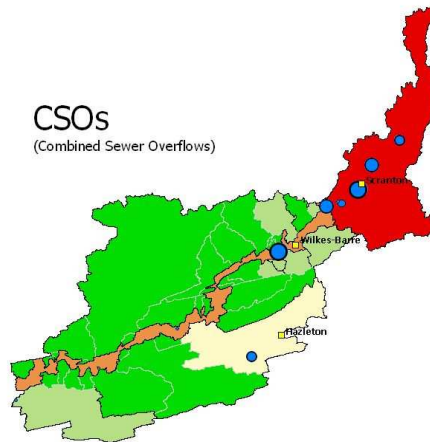
www.giscon.org
2010-2011

Regional and Local Environmental Indicators: Geospatial Overview

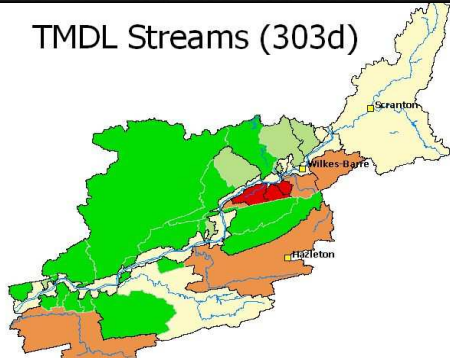
Upper Susquehanna – Lackawanna Watershed



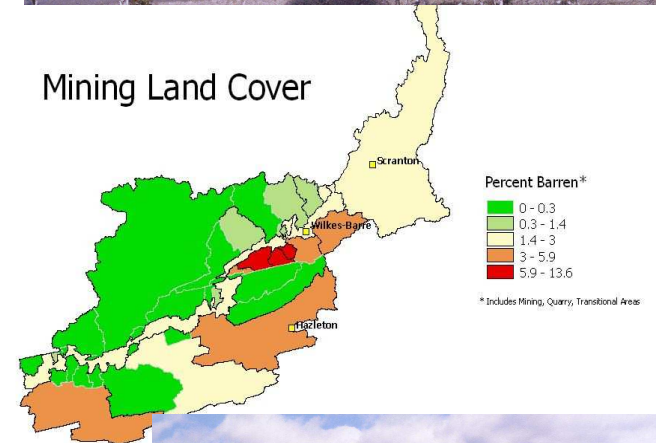
CSOs
(Combined Sewer Overflows)



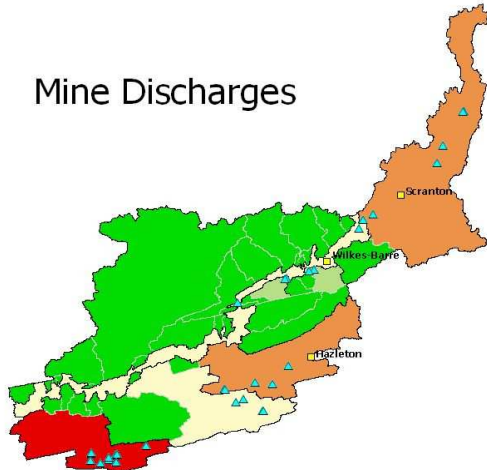
TMDL Streams (303d)



Mining Land Cover



Mine Discharges



CSO COUNT vs. Urban (sq. mi.)

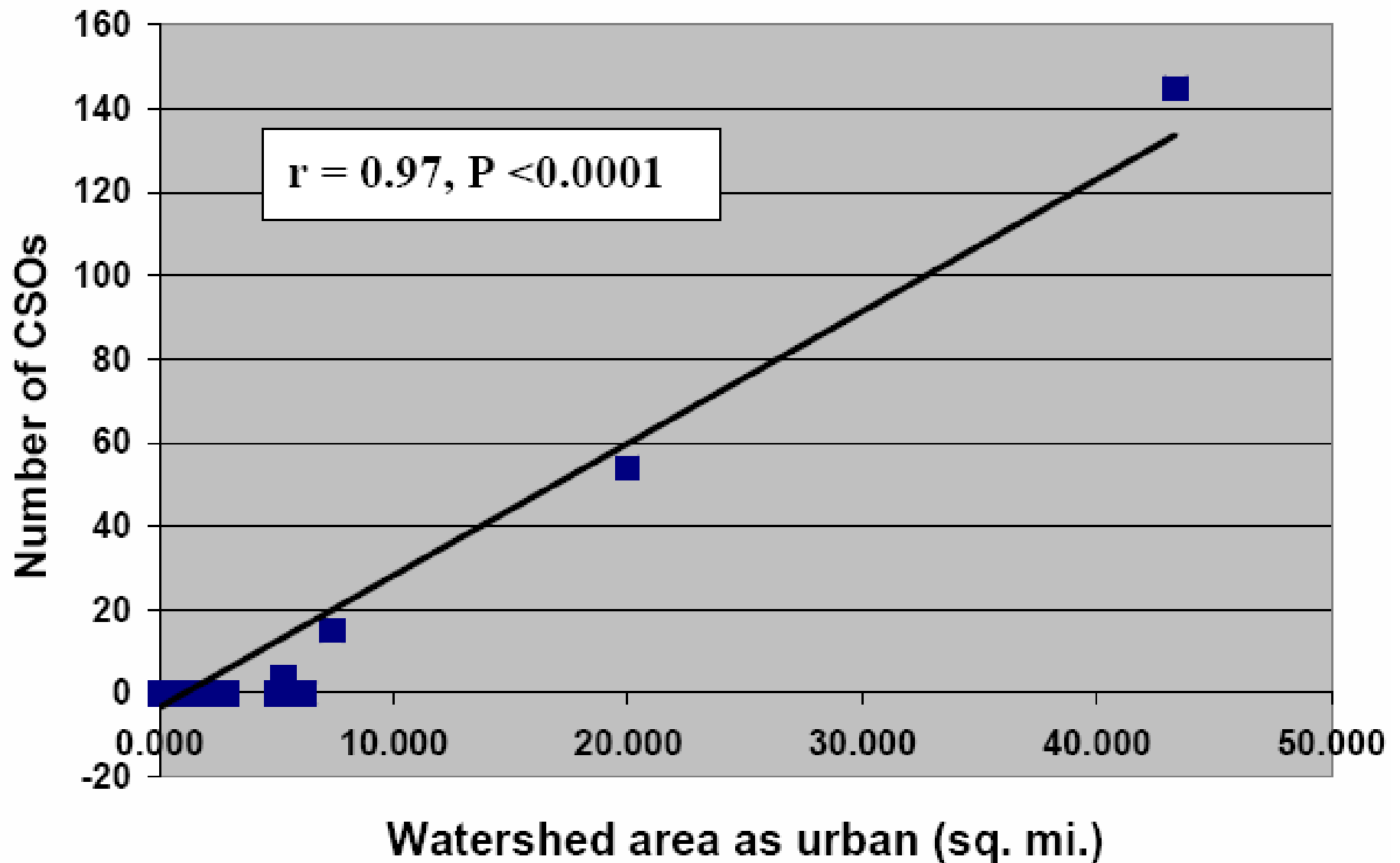


Figure 31. Number of CSOs in a watershed vs. square miles in urban land use .

Number of Wet AMD Outfalls vs. Mining area

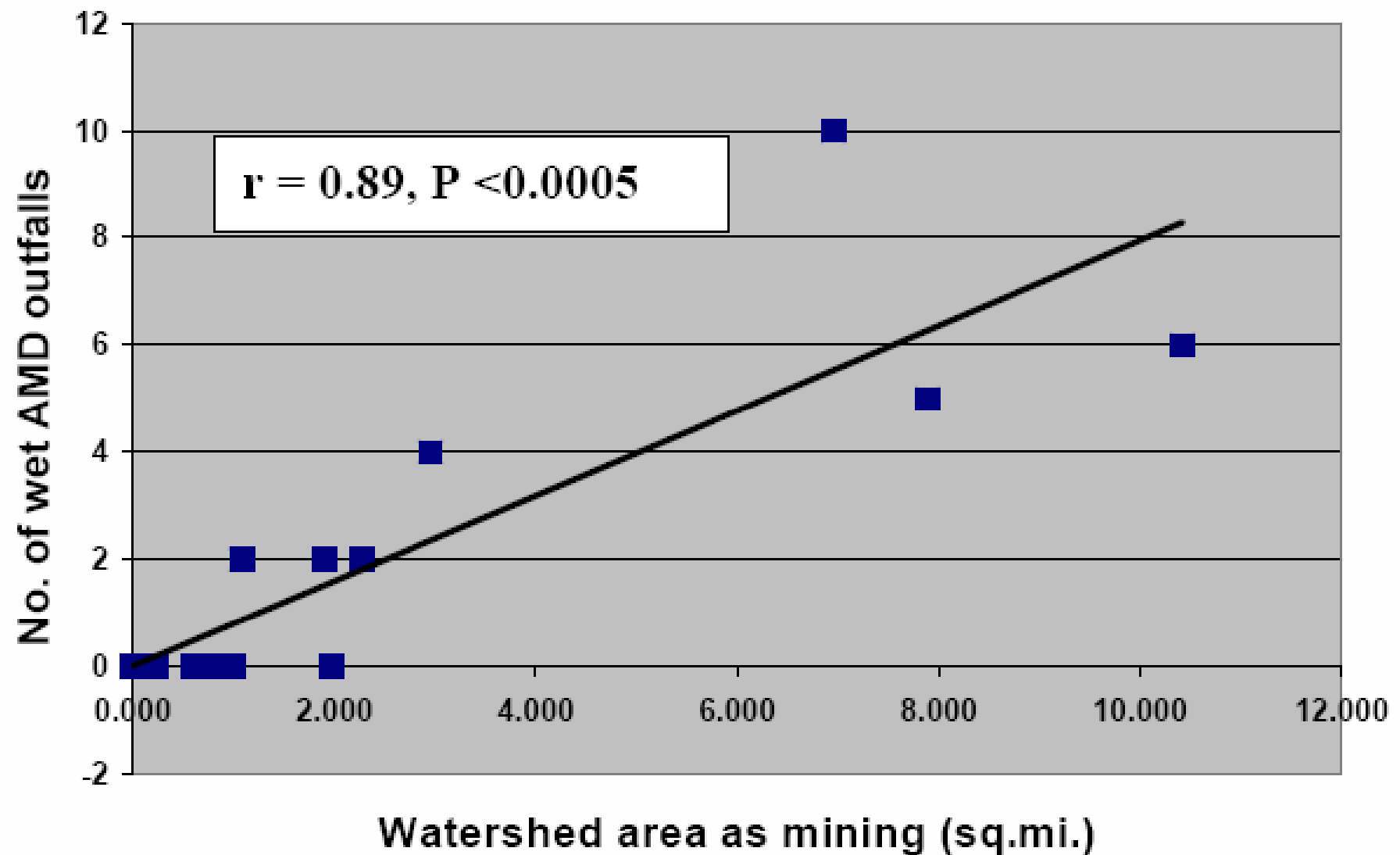


Figure 32. No. AMD outfalls in a watershed vs. square miles in mining land use.

**Regional
Landscapes -
(5 State Area)**

**Tributary
Watersheds
(10-400 sq.
mi.)**

**Local Stream
Reaches (e.g.,
300 m)**

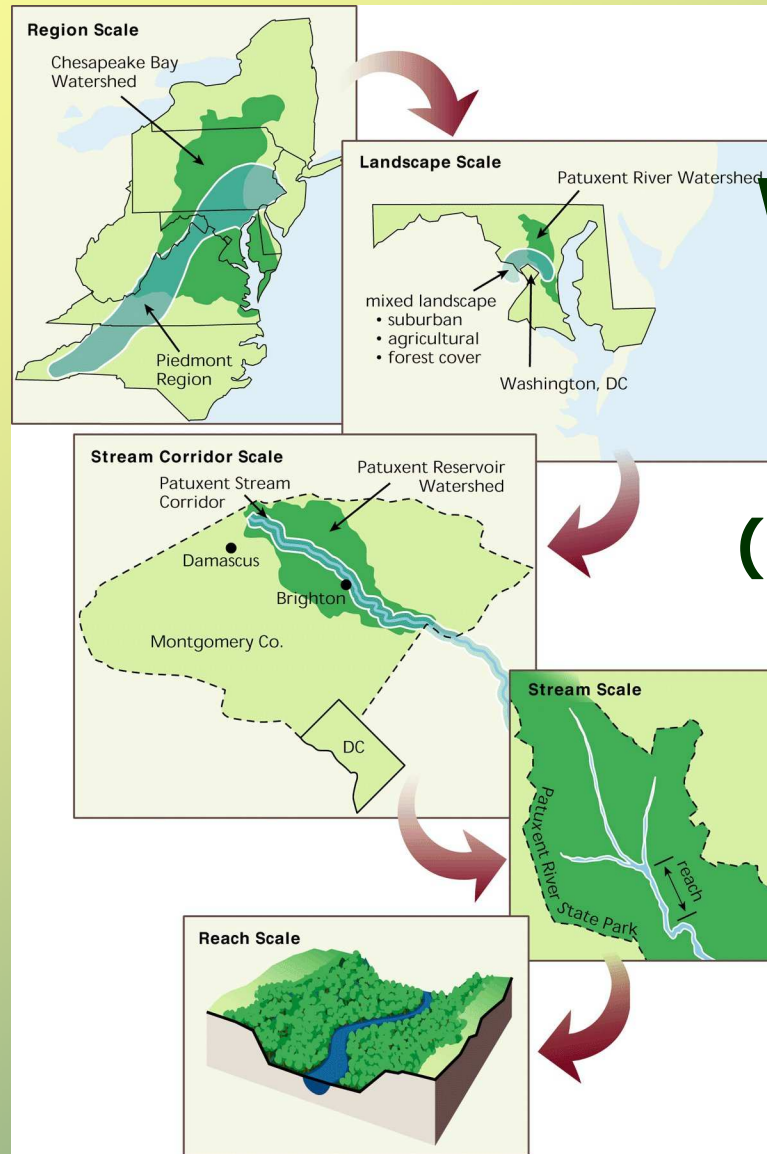
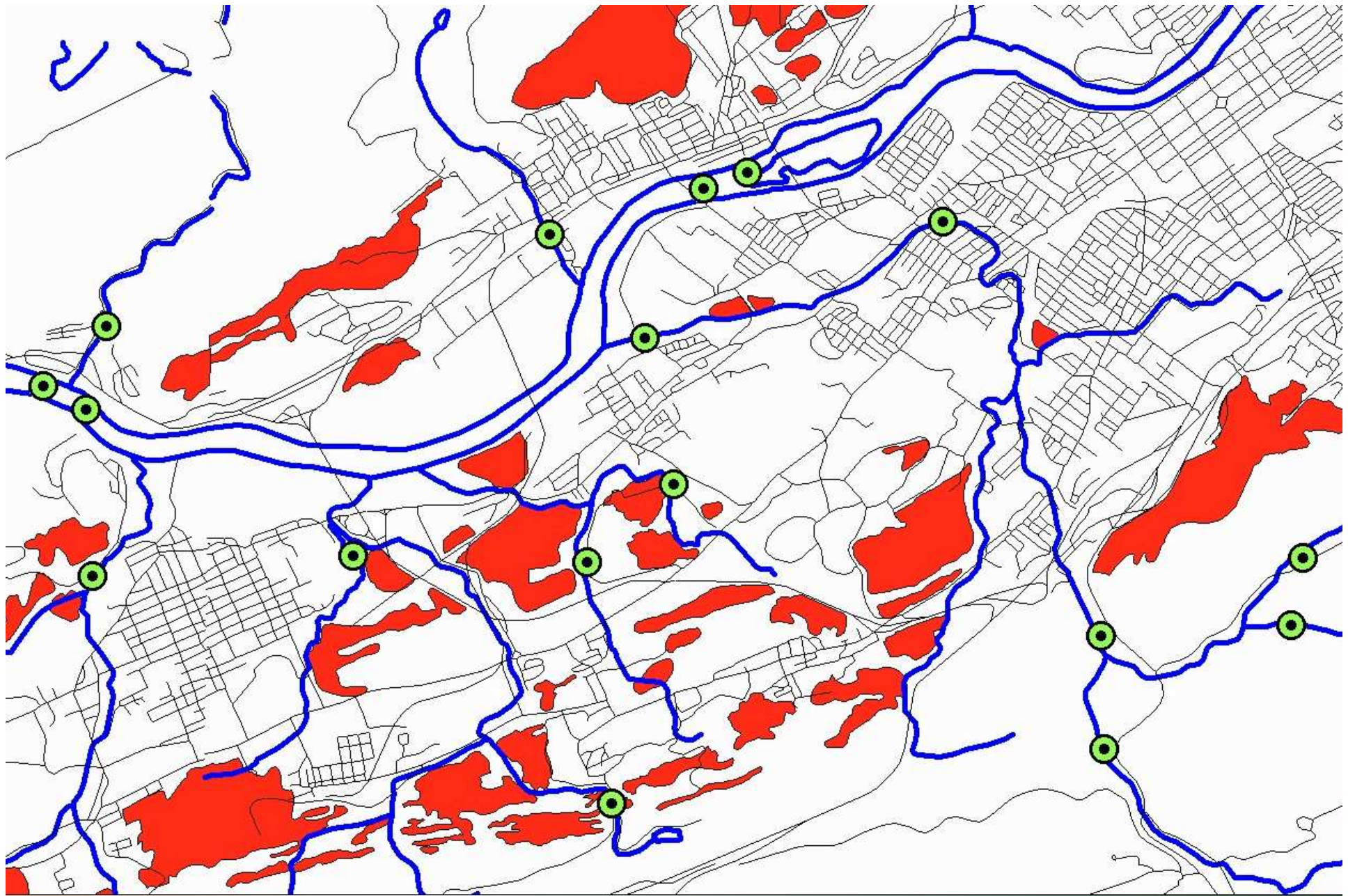


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**Spatial
Scales for
Watersheds**

**Regional
Watershed
(2000 sq. mi.)**

**Local
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Strip Mine



Culm Bank



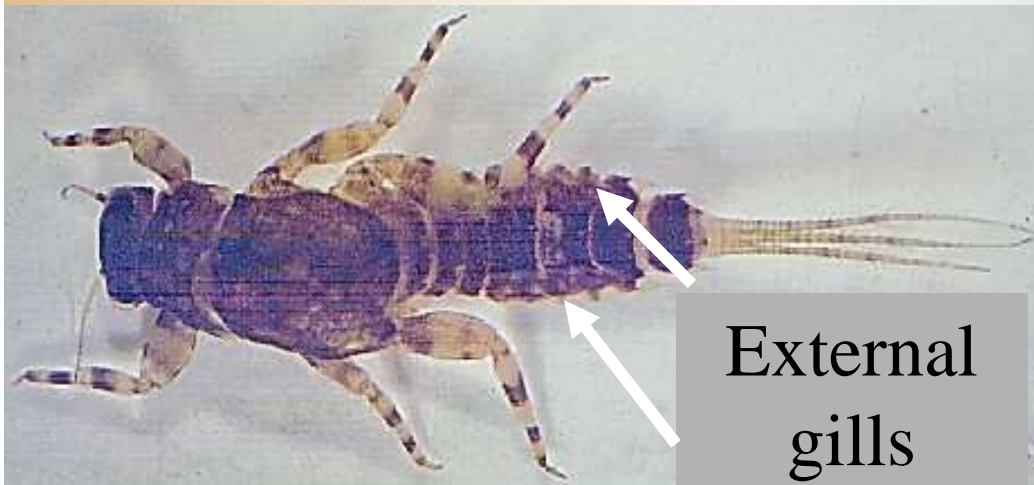
Reclaimed Land





Study design from systems approach

- Habitat variables measured (7)
 - Substrates (4 types, iron oxides from mining)
 - Flow
 - Stream size (order, link)
- Water chemistry (11)
 - pH, conductivity, iron (acid mine drainage)
 - Oxygen, nutrients (combined) sewer overflows
- Land Use (4) – forests, mining, urban, agriculture
- Dependent variables – ecological endpoints (10)
 - Aquatic insect communities (filter feeders, diversity)

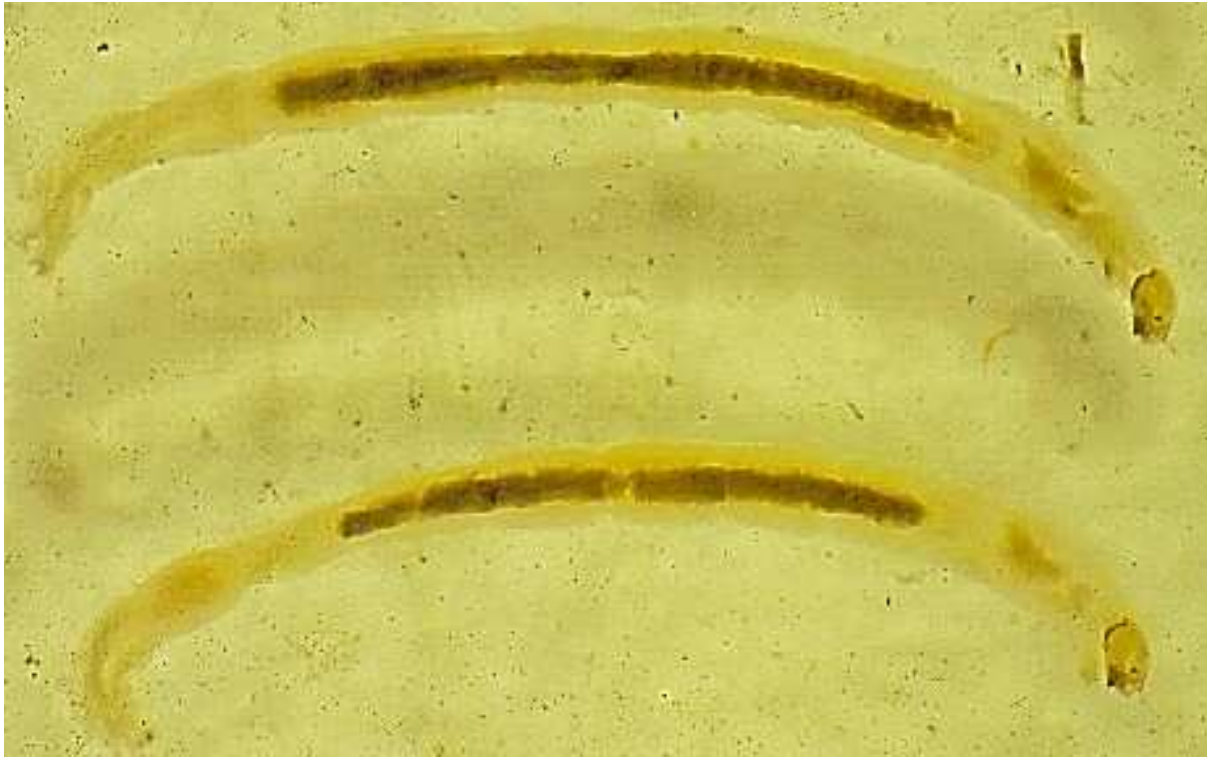


External
gills

Mayflies are indicators of “healthy” stream conditions and are important to the aquatic food web

From

<http://www.lrca.org/pages/macroinvertebrates/pages/Macroinvertebrates.htm>

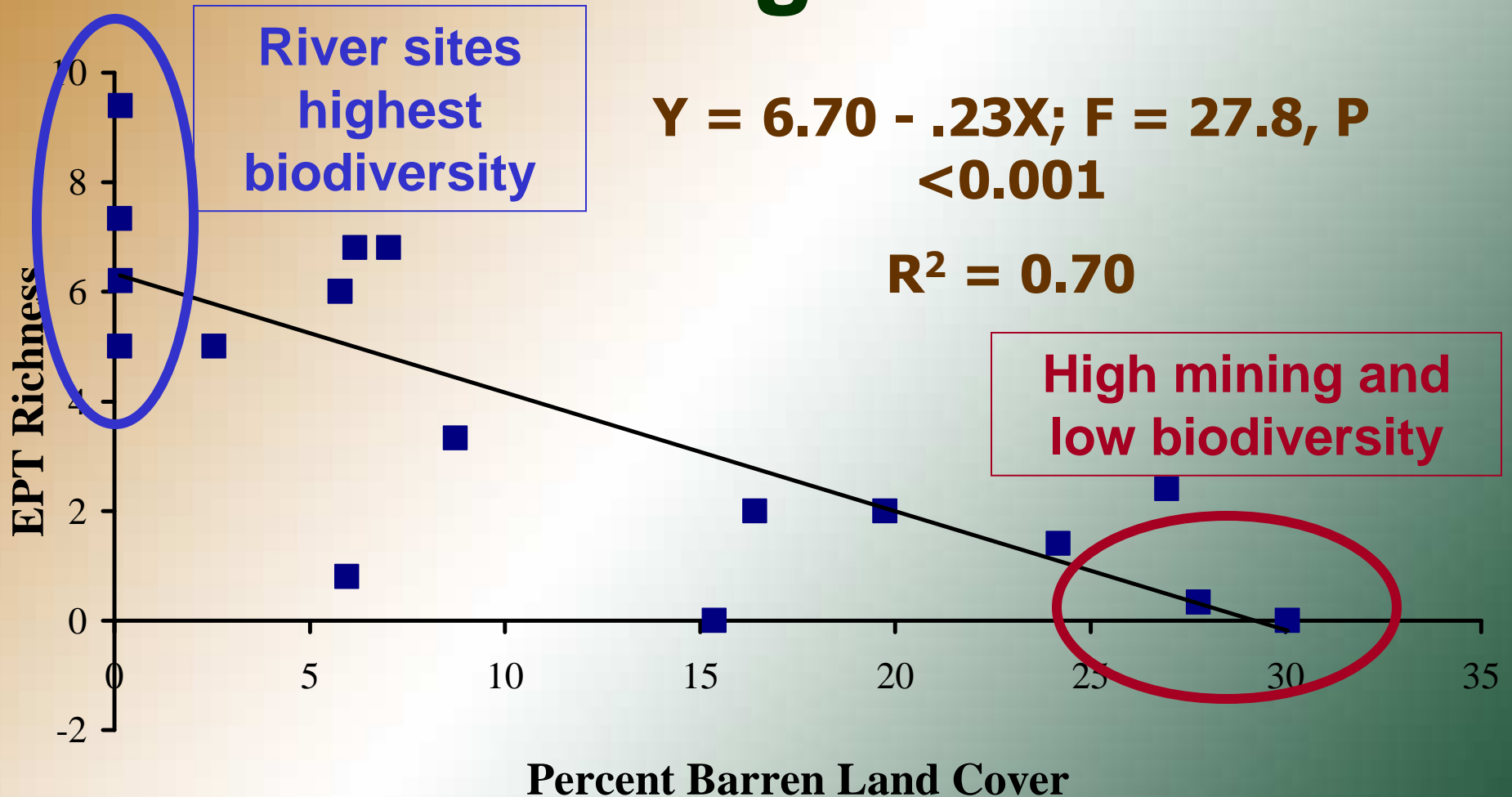


**Midgeflies
(top) and
blackflies
(bottom) are
pollution
tolerant
species**

- From [http://www.lrca.org/pages/macroinvertebrates/
pages/Macroinvertebrates.htm](http://www.lrca.org/pages/macroinvertebrates/pages/Macroinvertebrates.htm)

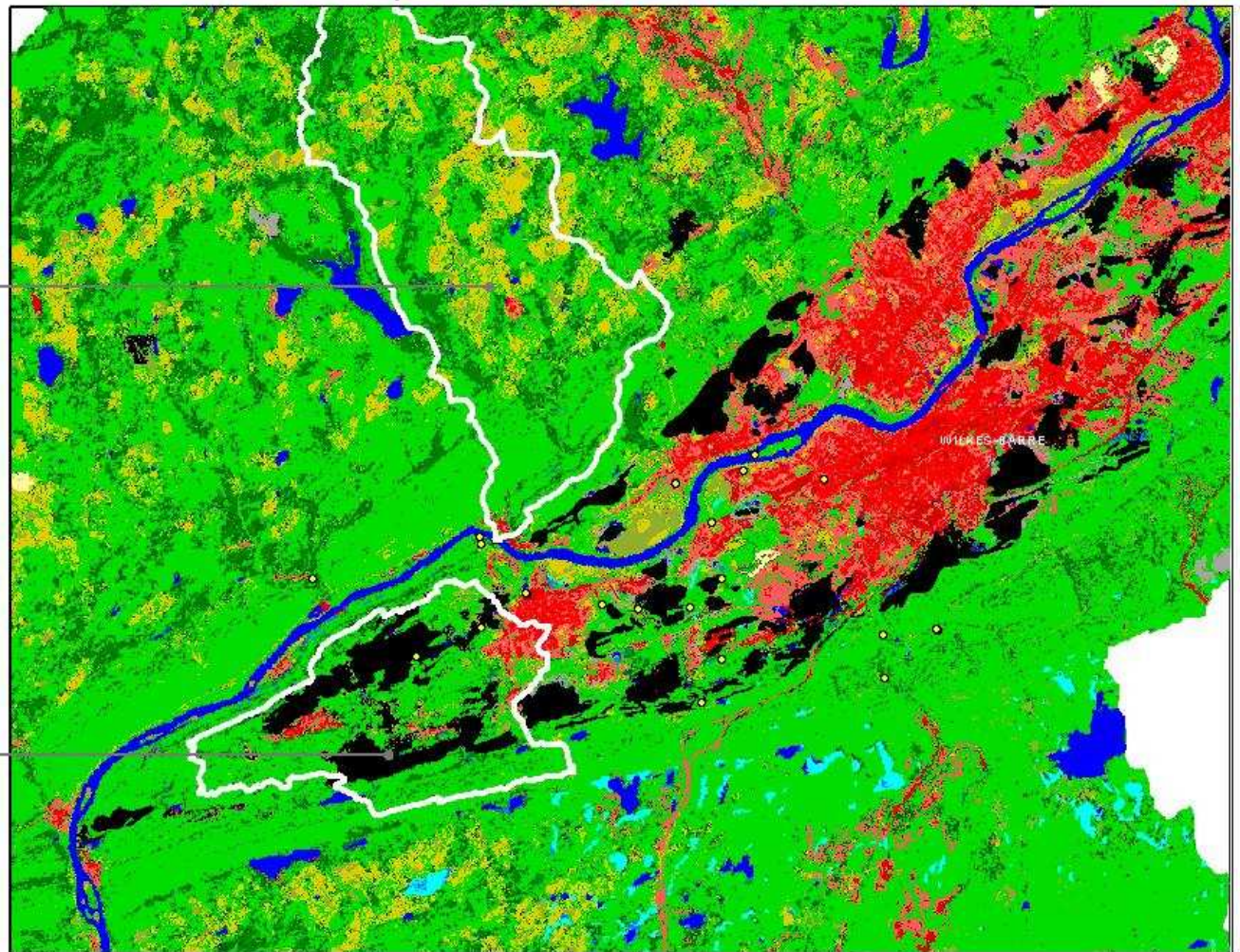
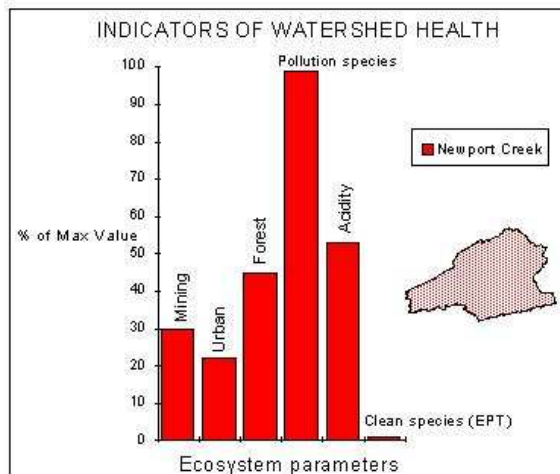
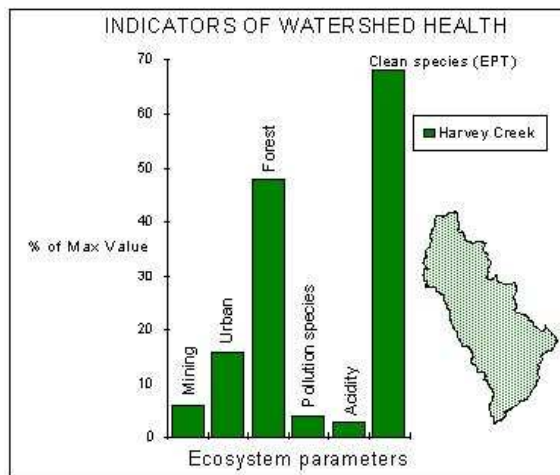


EPT Richness vs. Mining Land Cover



Landscape-Watershed Analysis

- land cover and water chemistry
- macroinvertebrate communities and related biodiversity index
- statistical correlations (land cover vs. water chemistry, macroinvertebrates and biodiversity)



Regional Landscapes - (5 State Area)

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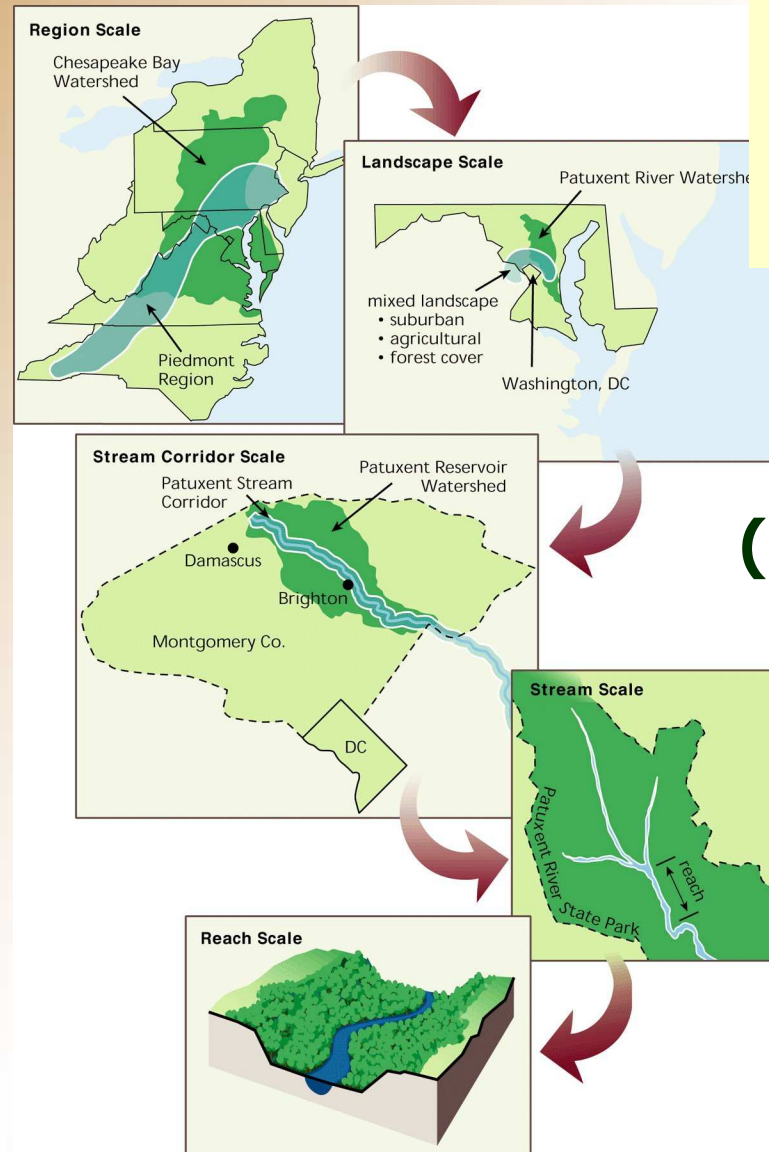


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Spatial Scales for Watersheds

**Regional
Watershed
(2000 sq. mi.)**

**Local
Watersheds
(1-5 sq. mi.)**

Forest = 67 %

Ag = 23%



Typical Gas Well Site



Image retrieved from: Independent Oil and Gas Association of Pennsylvania's, Drilling & Developing the Marcellus Shale

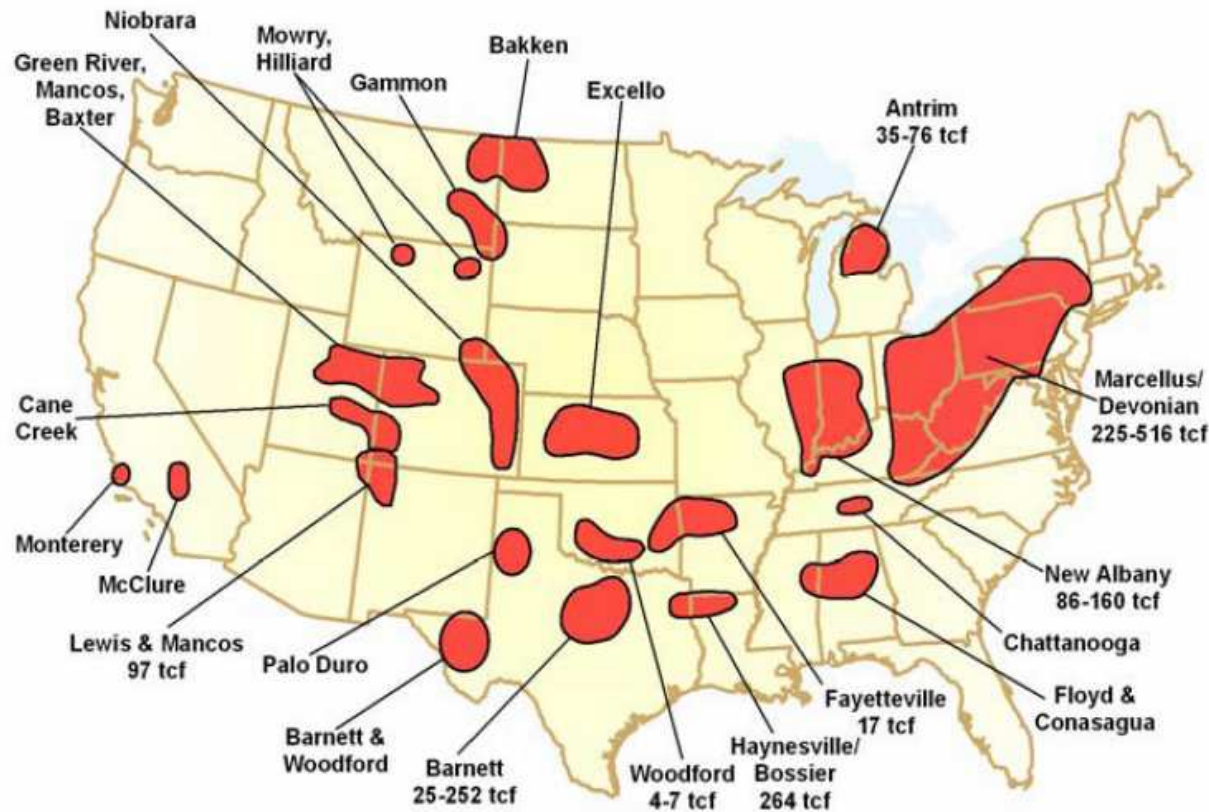


Susquehanna River Basin Commission

www.srbc.net



Figure 1: Gas Shale Basins of the United States



**What is
the next
energy
boom in
PA?**

**Marcellus Shale – gas field – largest
in U.S.; uses “hydro-fracking” –
enormous volumes of water and
wastewater involved**

Vertical vs. Horizontal Drilling

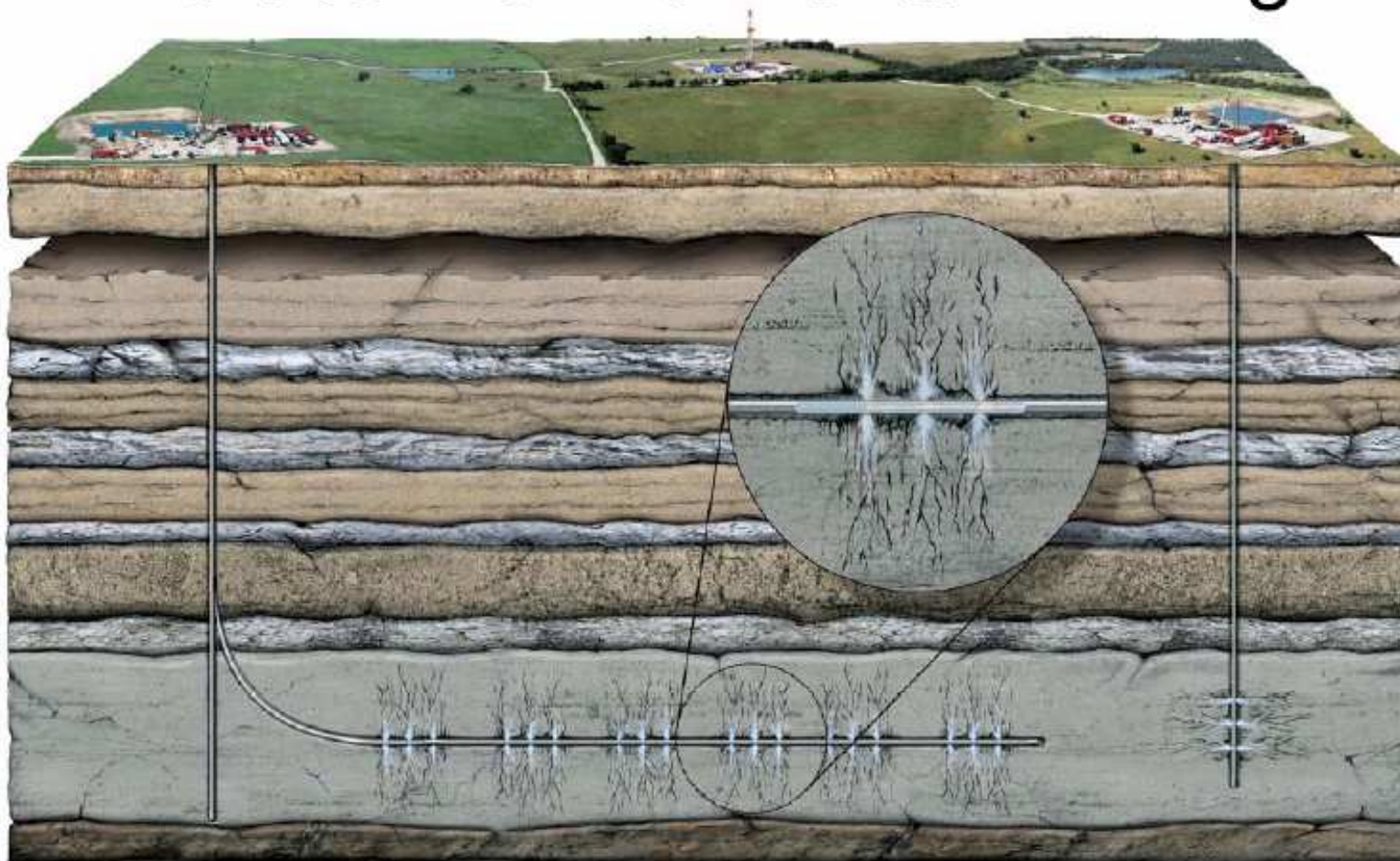


Illustration retrieved from: Independent Oil and Gas Association of Pennsylvania's *Drilling & Developing the Marcellus Shale*



Water Resources and Natural Gas Production from the Marcellus Shale

By Daniel J. Soeder¹ and William M. Kappel²

Introduction

What is the Marcellus Shale?

Why is the Marcellus Shale an Important Gas Resource?

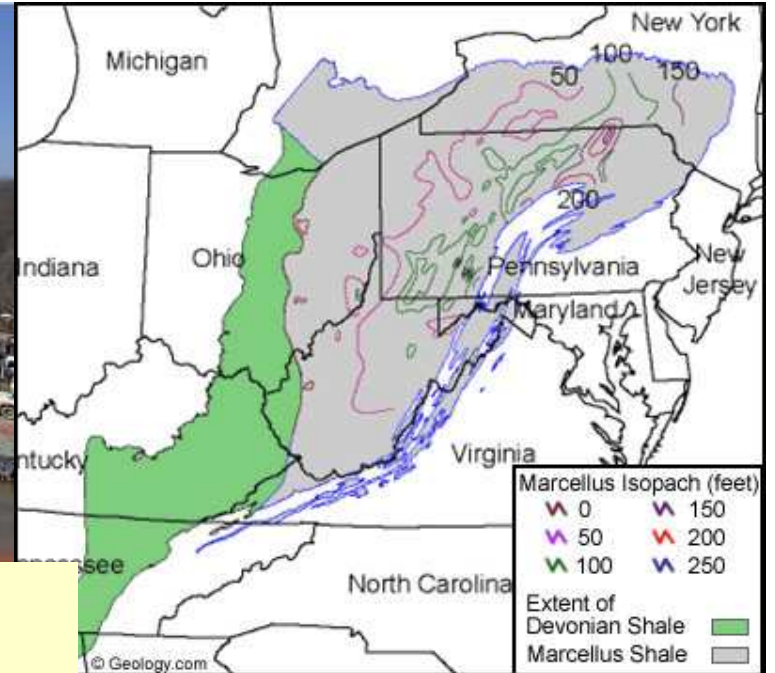


Figure 7. Example of a gel used in hydrofracturing to carry proppant into a fracture. Photograph by Daniel Soeder, USGS.

Typical Gas Well Site



Image retrieved from: Independent Oil and Gas Association of Pennsylvania's, Drilling & Developing the Marcellus Shale



Issues:

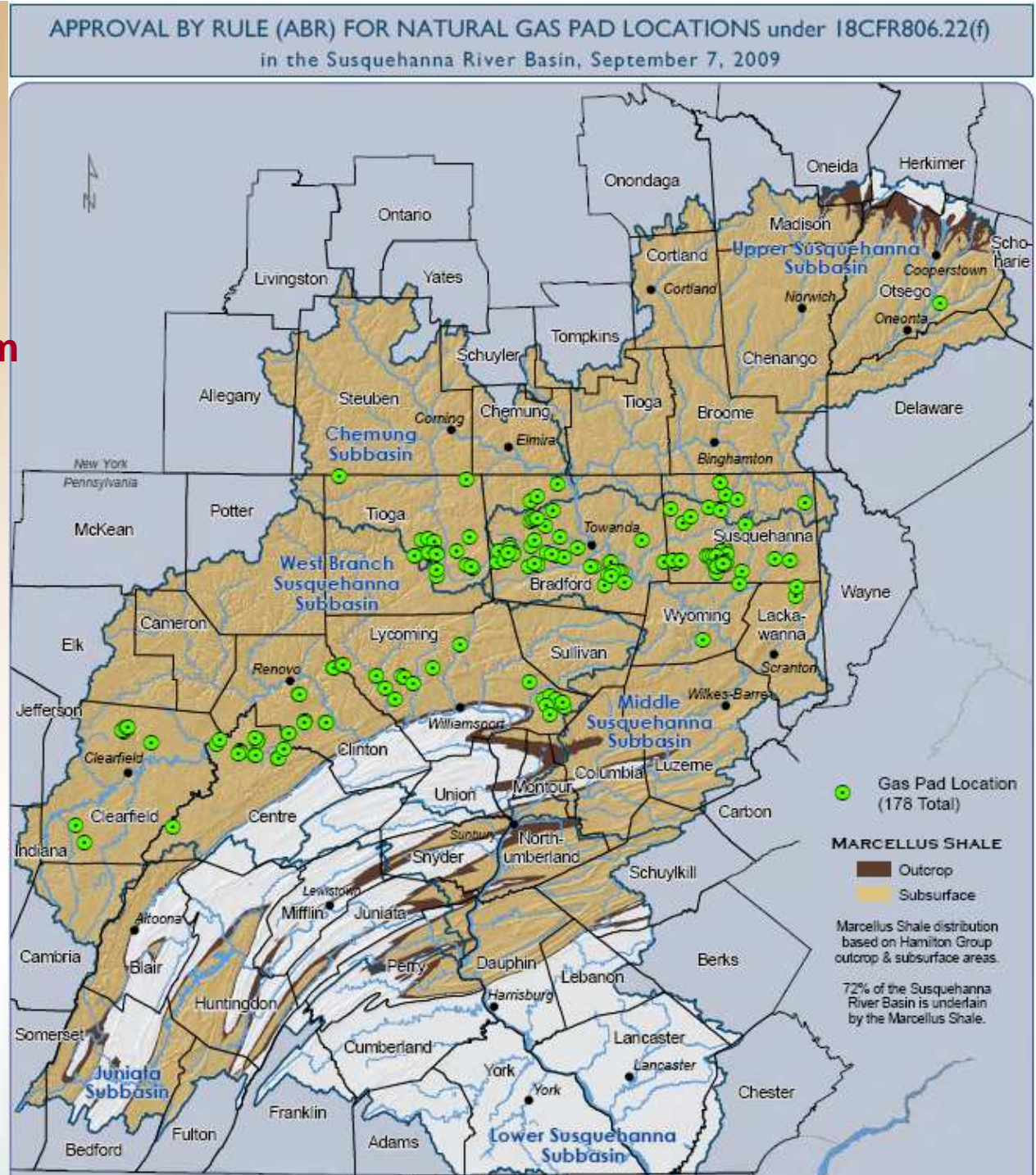
- Trucks and noise;
- Potential water quality and river ecology impacts;
- Potential affects on ecological habitats;
- Public concerns (outreach and education);
- Water resources;
- Water recovery and treatment;
- Land use and quality of life





<http://www.srbc.net/programs/projreviewmarcellus.htm>

**Did our AHR
monitoring
and
assessment
program
anticipate gas
development?
Or help us?**



Increased salinization of fresh water in the northeastern United States

PNAS | September 20, 2005 | vol. 102 | no. 38 | 13517–13520

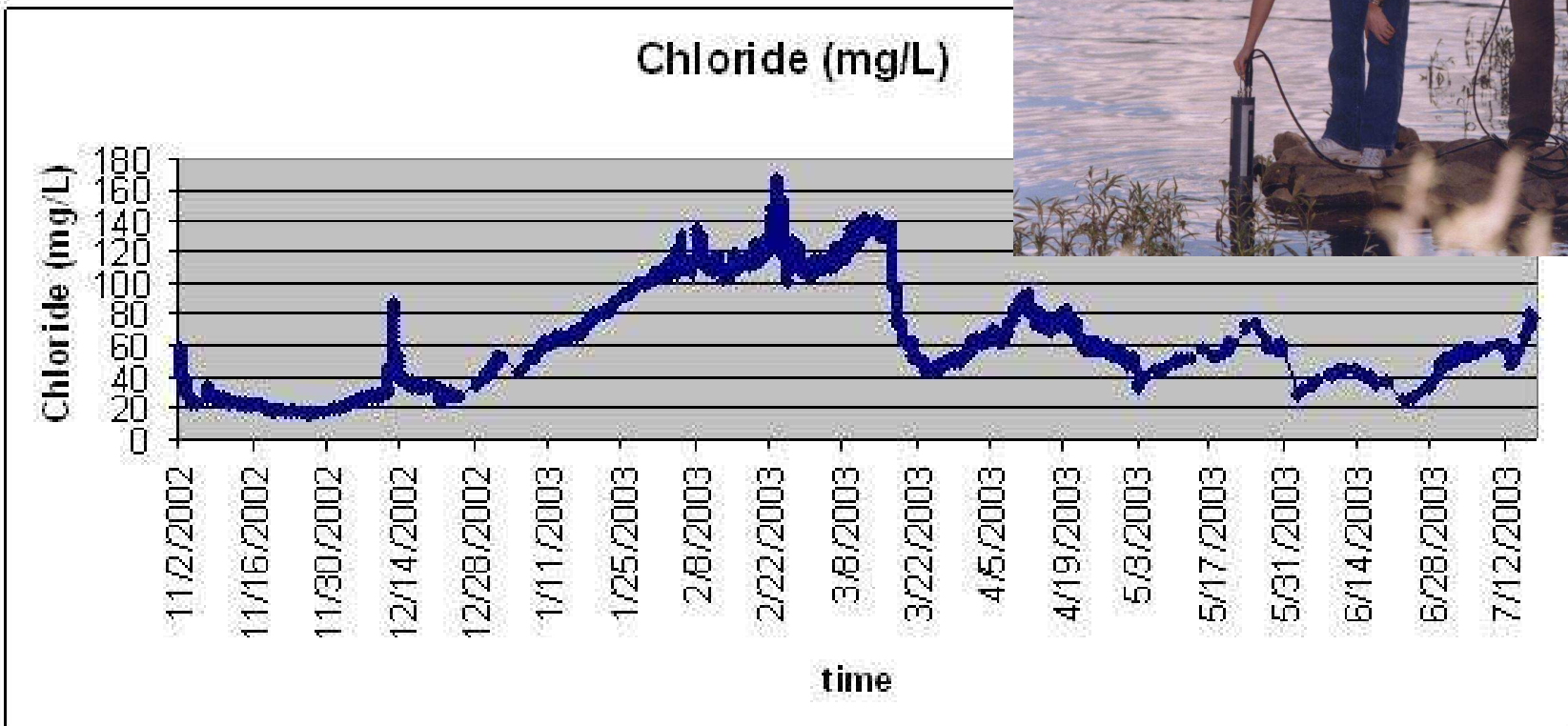
Sujay S. Kaushal^{*†‡}, Peter M. Groffman^{*}, Gene E. Likens^{*‡}, Kenneth T. Belt[§], William P. Stack[¶], Victoria R. Kelly^{*}, Lawrence E. Band^{||}, and Gary T. Fisher^{**}

^{*}Institute of Ecosystem Studies, Box AB Route 44A, Millbrook, NY 12545; [§]U.S. Department of Agriculture, University of Maryland Baltimore County, Baltimore, MD 21227; [¶]Baltimore Department of Public Works; ^{||}Department of Geography, University of North Carolina, Chapel Hill, NC 27599; and ^{**}U.S. Geological Survey

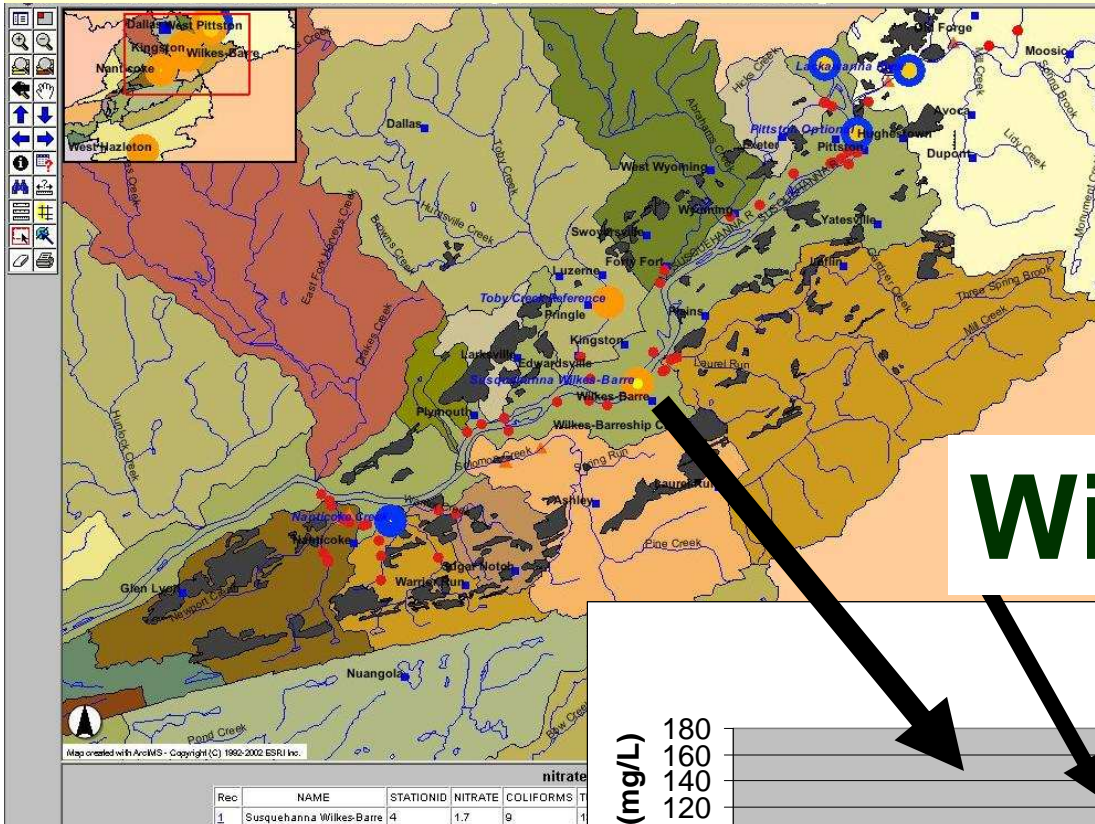
Contributed by Gene E. Likens, August 4, 2005

Chloride concentrations are increasing at a rate that threatens the availability of fresh water in the northeastern United States. Increases in roadways and deicer use are now salinizing fresh waters, degrading habitat for aquatic organisms, and impacting large supplies of drinking water for humans throughout the region. We observed chloride concentrations of up to 25% of the concentration of seawater in streams of Maryland, New York, and

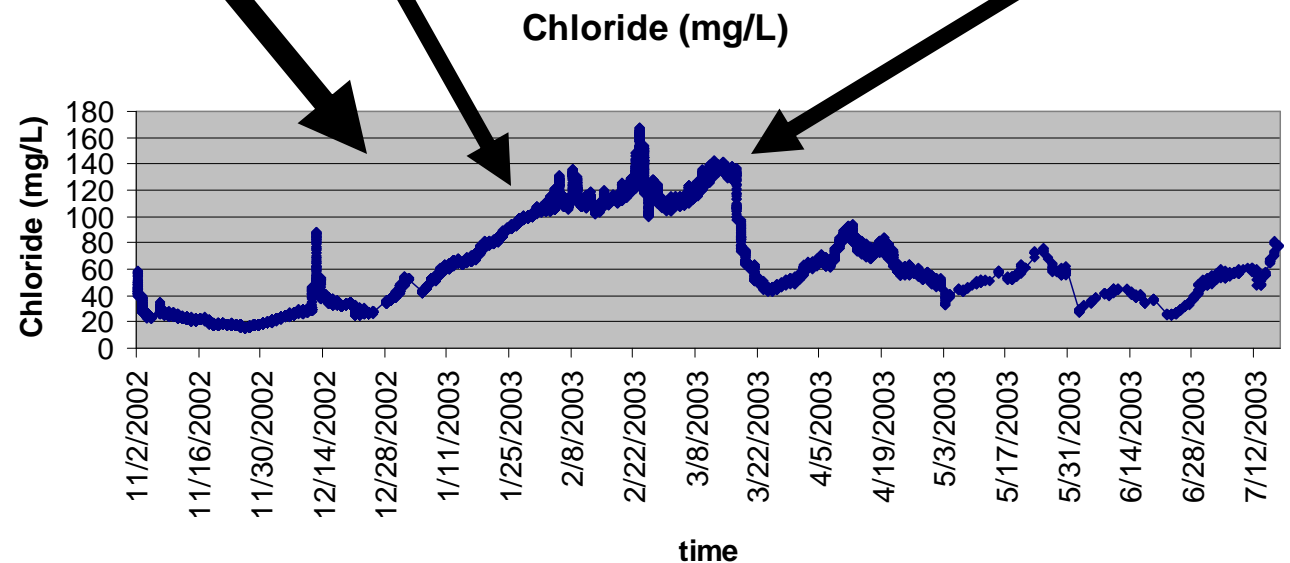
exists (8). Regulate the Canadian government. Relatively little is known about the widespread increases in long-term changes in chloride concentrations in the United States. Impacts on the United States,



RIVERNET – WEB GIS for WATERSHED-WATER QUALITY DATA



Winter road salt

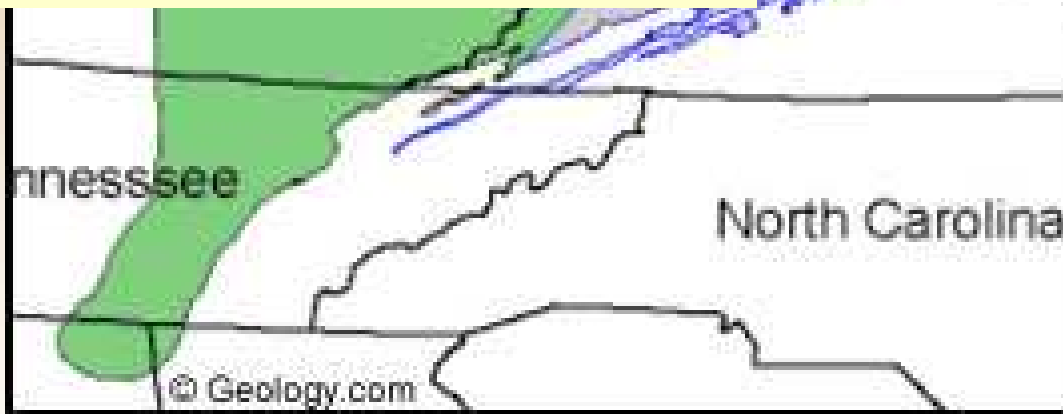
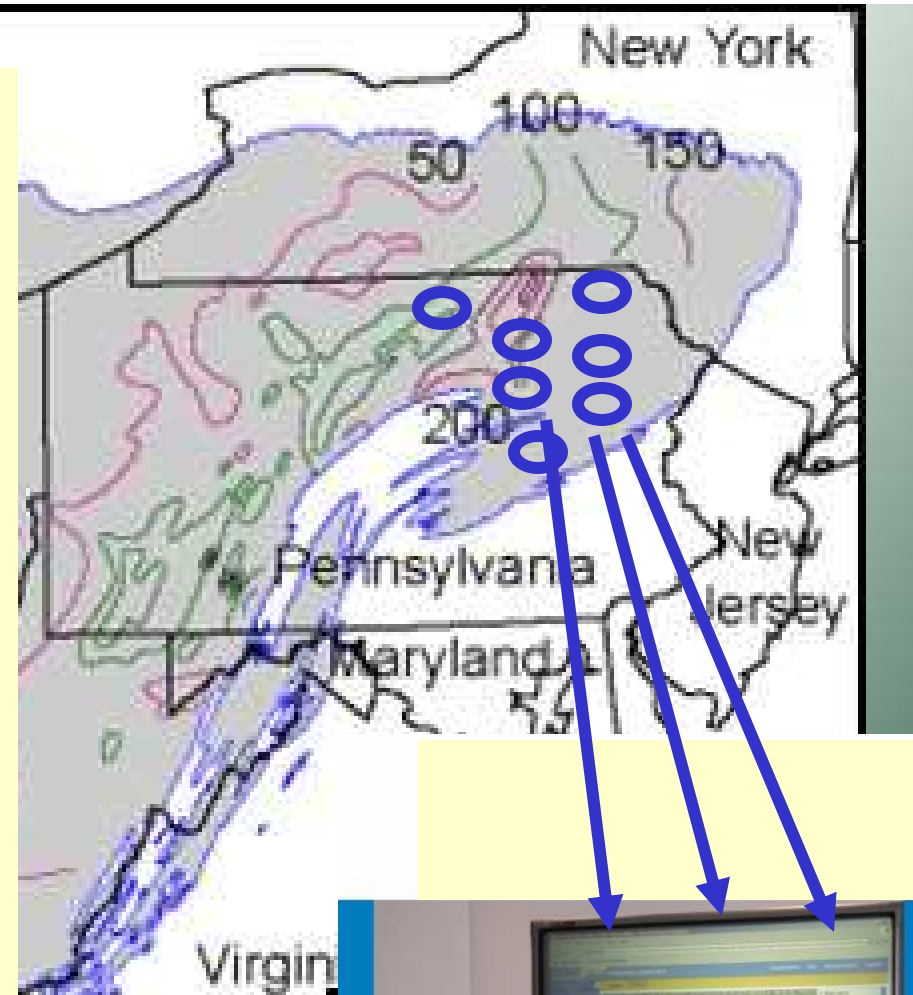


**Real-time field
measurement – integrated
with Web-based public
education-outreach**

AND

**Testing and design of
waste water treatment**

**(Reverse Osmosis – very
expensive)**



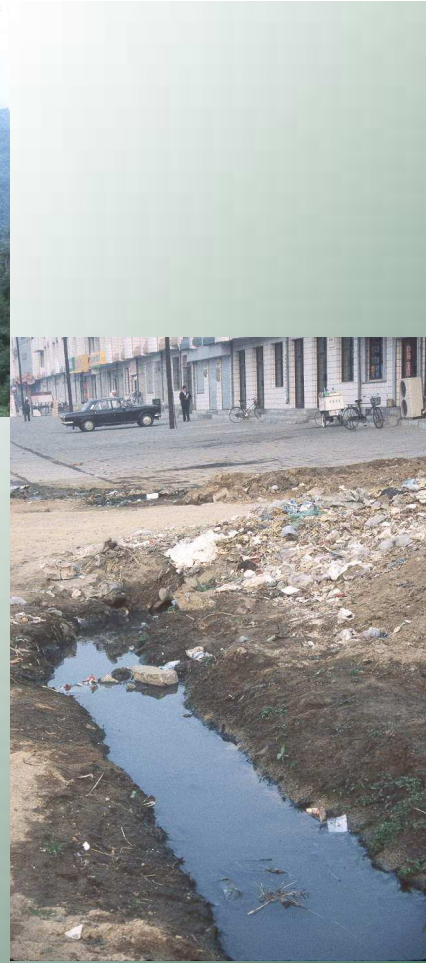
Jeff Davidson pinpoints a location in the emergency operations center

**EMA team expedites its disaster
SMART Board interactive whit**



Conclusions

- Regional landscape analysis (EPA) reflected agency priorities: **ag runoff and urban affects**
- Community outreach identified: **CSOs and mining** impacts in populated urban areas of AHR watershed
- Local watershed analysis – reflected **spawl issues** and flooding from storm runoff
- Baseline monitoring and approach – could help in **resource management for gas field**
- Scale of study reflects the problem you encounter and address – **need a range of approaches**



**Final
shots –
questions
?**

